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Techniques for Elk Immobilization with Succinylcholine Chloride

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Marking individual elk was necessary to enable a study of their movements at Wind Cave National Park. Elk were immobilized with succinylcholine chloride (20 mg/cc) by using syringe darts. Twenty adult bulls were immobilized in a modified bison corral trap baited with salt; four adult cows and a six-month-old female calf were immobilized from a helicopter; and a single free-ranging adult cow was immobilized from the ground. The mean drug dosage used for successful immobilization was 27.0 mg for adult bulls and 24.4 mg for adult cows. Dosages necessary to immobilize bulls and cows differed significantly ($P < 0.05$). Bulls became immobilized an average of 8.8 minutes after injection and cows after 11.8 minutes; these times were not significantly different ($P > 0.05$). There was no difference ($P > 0.05$) in the average period of immobilization, 43.2 minutes for bulls and 42.6 minutes for cows. Succinylcholine chloride was slow-acting and sometimes caused death. Adult bulls in the vicinity of the corral readily entered the baited trap. Use of a helicopter was more effective than blinds, drives, or stalking for immobilization of free-ranging cows. The corral method was less costly than ground immobilization.
INDEX DESCRIPTORS: Elk, Immobilization Techniques, Succinylcholine Chloride.

A study to learn herd organization and movements of Rocky Mountain elk (*Cervus canadensis nelsoni*) that was conducted in Wind Cave National Park, South Dakota, from June, 1973, through February, 1975, required capture and marking of individual elk. Adult elk were immobilized with succinylcholine chloride (20 mg/cc) manufactured by E. R. Squibb and Sons, Inc., of New York; the drug was delivered in syringe darts from an immobilizing gun. Previously, researchers successfully used this drug on elk (Flook *et al.*, 1962; Harper, 1965; Denney, 1966; Craighead *et al.*, 1973).

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STUDY AREA

The park is a 28,059-acre tract located in the southeastern foothills of South Dakota's Black Hills. Topography consists of flat to rolling prairie areas cut by deep and wooded intermittent stream courses and north-south wooded ridges. Mixed-grass prairie covers about three-fourths of the park; the remaining one-fourth is covered by a ponderosa pine (*Pinus ponderosa*) forest, found primarily in the northwestern portion of the park. Elevations range from 3,646 to 5,013 feet MSL and average annual precipitation is about 18 inches (U.S. Soil Conservation Service, 1969).

Market hunting virtually eliminated elk from the Black Hills by 1900 (Hipschman, 1959). Forty-six elk were transplanted to the park from the Jackson Hole, Wyoming, area from 1914 to 1916 (Lovaas, 1973).

METHODS

Immobilizing guns and syringe darts were manufactured by Palmer Chemical and Equipment Company of Douglasville, Georgia. Elk were immobilized by shooting them in the hip with a 2- or 3-cc syringe dart equipped with 1¼ to 1½-inch needles and filled with the desired dosage of drug. Normally darts were propelled from either a CO_2 gun or a powder charge gun, but a crossbow and long bow were used occasionally.

An elk collapsed after a few minutes, if an adequate dosage was injected. It was then quietly approached and, in the case of antlered bulls, was blindfolded to calm the animal (Harthoorn, 1965) before a collar and ear tags were attached. If the elk fell onto its side, it was immediately rolled onto its brisket to prevent death from bloating, suffocation, or inhalation of rumen contents (Talbot and Lamprey, 1961; Flook *et al.*, 1962; Harper, 1965). In addition, the elk's head was held up if it could not do so under its own power, to aid its breathing. Artificial respiration by rhythmic pumping of the rib cage was attempted on elk that either stopped breathing or were breathing very irregularly. An immobilized elk was tended until it began to recover and was watched until able to stand. Elk were not weighed or aged.

Bait trapping was conducted from October, 1973, through January, 1974, and in July and August, 1974, at a corral trap. This trap was originally built for bison but later modified to hold elk (Lovaas, 1973). The trap consisted of two wing fences that led into a 40-acre holding pasture. A smaller corral with adjacent holding pens was at one end of the pasture. During trapping, the main 27-foot gate was opened and several salt blocks were placed in the middle of the holding pasture. In addition, a salt block was placed just inside the gate and another approximately 200 yards outside, between the wings. The trap was checked periodically just before dawn and the gate manually closed to capture any elk baited into the holding pasture. A vehicle was used to herd elk into the

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smaller corral. Individuals were put into single holding pens where they were immobilized and marked.

Attempts to immobilize free-ranging elk on the ground commenced in early October, 1973, and continued through mid-December. Three methods used to immobilize elk from the ground were drives, stalking, and blinds.

Drives on foot, involving eight researchers, were conducted in mid-October, 1973, in areas where elk were located. Drivers, spread out in a line at 100-200 yard intervals, walked in the direction of ambushers who were hidden some distance away. A crossbow, long bow, CO_2 gun, and a powder charge gun were used by the shooters. Ambushers who shot elk were joined by others to search for the animal.

Stalking attempts also were made when possible. Because large herds characteristically had several of their members on alert at any one time, only small groups or single animals were stalked. Primarily, the powder charge gun was used in this method; accurate shots could only be made when the stalker was within 45 yards of the animal. Good stalking techniques (wearing drab clothing, downwind approach, quietness, etc.) were necessary because elk were extremely wary of humans, but somewhat less wary when approached in a prone position (Lovaas, 1974).

A method that combined both stalking and the use of natural blinds (large rocks, trees, etc.) also was used periodically. On several occasions during early morning hours, a herd was seen grazing in the open. The ambusher, armed with a powder charge gun, quietly selected a downwind natural blind located where elk were likely to pass when they walked into the woods to bed down for the day. A shot was attempted when an elk came within range of the gun.

Generally, when immobilizing free-ranging elk on the ground, 5-10 minutes were allowed between shooting and pursuit to prevent the animal from becoming excited and moving a long distance before the drug took effect (Harper, 1965).

A helicopter was used to immobilize free-ranging female elk in January, 1974. The shooter sat in the right-hand seat as the helicopter flew low over a cow-calf group that had been herded into an open area. A single elk was split off from the main herd, and the pilot would position the helicopter parallel to and a little behind the running animal. Elk were shot from a distance of 30 feet or less; the helicopter flew 10 to 15 feet off the ground and at the same speed as the running elk. After the shot, the helicopter was successfully used to herd the animal away from wooded cover, in most instances. Elk were watched until it was evident that the drug would have no effect, until the animal disappeared in heavy timber, or until it collapsed and could be marked.

RESULTS

Twenty-three adult bulls were captured in the corral trap from October, 1973, to January, 1974, and two more were captured in the summer of 1974. This does not include one bull that escaped before the gate was closed and two that jumped the corral fence after being trapped. No cows or calves were attracted to the baited trap, but the area where the trap was located was not commonly frequented by cows. Of 25 bulls immobilized in the corral, five died of what seemed to be a drug overdose (Table 1).

Twelve free-ranging elk were shot using ground immobilization methods. Driving was the least successful method used; only an adult cow and a yearling bull were hit. Stalking was the most successful, with hits on five adult cows and one adult bull. Two adult bulls and two yearling bulls were hit from natural blinds. It was difficult to follow or find elk that escaped into rough, wooded areas after they were hit. Only one cow was successfully stalked, immobilized, and marked. This cow had traveled about 600 yards before collapsing and was found lying in a large meadow. Two bulls (one yearling and one adult) traveled 150 and 300 yards, respectively, before collapsing. Approximately 45 minutes were spent searching for each, but the yearling evidently died of an overdose, and the adult recovered from the effects of the drug and ran when approached.

TABLE 1. A COMPARISON OF DOSAGE, LATENT PERIOD, AND DOWN TIME BETWEEN BOTH SEXES OF ADULT ELK SUCCESSFULLY IMMOBILIZED OR KILLED WITH SUCCINYLCHOLINE CHLORIDE

	Successful		*Fatal*	
	Bulls	*Cows*	*Bulls*	*Cows*
Dosage (mg)				
Number	21	5	5	2
Range	23-35	24-25	27-30	25[1]
Mean (± S.E.)	27.0 ± 0.6	24.4 ± 0.2	27.6 ± 1.2	
Minutes to collapse				
Number	20	4	5	2
Range	5-15	10-15	2-6	2-15
Mean (± S.E.)	8.8 ± 0.7	11.8 ± 1.2	4.3 ± 0.7	8.5 ± 6.5
Minutes immobilized				
Number	17	5		
Range	22-82	30-60		
Mean (± S.E.)	43.2 ± 3.8	42.6 ± 5.3		

[1] Upper range value was unknown.

Forty-seven darts were shot at female elk from a helicopter, resulting in 30 hits and 17 misses. In 19 hits, the dart bounced out of the animal and it seemed that the drug was not injected or only partly injected. In the remaining 11 hits, two cows escaped into thick woods before the effectiveness of the drug could be determined, one cow was not immobilized (perhaps because of a failure in the dart), two cows died (perhaps because of an overdose), and five elk were immobilized (one was shot twice) and marked. The elk marked successfully were four adult cows and a six-month-old female calf. Eleven hours of flight time were used to immobilize and mark these five elk.

Information concerning the successful immobilization of the four adult cows by helicopter and the one on the ground is found in Table 1. The six-month-old calf was shot with a 26-mg dosage, but the dart bounced out and the calf probably received only part of the dosage.

One dart bounced out of the first of two cows that died of a drug overdose. After waiting 15 minutes, the researchers shot this cow again, on the assumption that the initial dart had failed to inject any drug. This cow may have received some drug from the first dart. The other cow died after being injected with a seemingly normal dosage of 25 mg (Table 1). Attempts to revive overdosed elk through artificial respiration were unsuccessful.

DISCUSSION

Adult bulls in the vicinity of the corral readily entered the baited trap. Cow-calf herds used other areas of the park and

TABLE 2. COMPARATIVE COST OF DIFFERENT TECHNIQUES USED TO SUCESSFULLY CAPTURE AND MARK ELK AT WIND CAVE NATIONAL PARK USING SUCCINYLCHOLINE CHLORIDE

	Corral Trap		*Ground Immobilization*		*Helicopter Immobilization*	
Expenses[1]	*Estimated Number of Units*	*Cost*	*Estimated Number of Units*	*Cost*	*Estimated Number of Units*	*Cost*
Vehicle mileage (15¢/mi.)	300	$ 45	1.200	$ 180	100	$ 15
Man-days effort ($30/day)	15	$450	74	$2,220	7.5	$ 225
Dart losses ($6/dart)	0	0	9	$ 54	41	$ 246
Helicopter hours[2]					11	$ 915
Total cost		$495		$2.454		$1,401
Number marked	20		1		5	
Estimated cost per elk		$ 24.75		$2.454		$ 280.20

[1] Marking device and drug costs not included.

[2] Commercial flying service used for six hours at $110/hr. (plus $205 towing charges) for a total cost of $865. A National Guard helicopter and pilot were used for five hours at $10/hr. for a total cost of $50.

were seldom seen within one mile of the structure, but cows and calves were captured in the trap by baiting in some previous years (Allan L. Lovaas, Biologist, Wind Cave National Park, personal communication). Cows and calves might have been captured if similar traps had been located within areas they utilized.

Flook *et al.* (1962) and Craighead *et al.* (1973) reported successful immobilizing of elk on the ground, but failed to emphasize the influence of such factors as wariness of the elk, or vegetation and/or terrain features. Harper (1965) reported successful immobilization of relatively unwary elk in Oregon. At Wind Cave, elk were extremely wary and ran for cover at any sign of danger. Elk were most easily approached in rough, wooded areas of the park, but it was difficult to find elk in such areas after they were hit. Lack of snow cover hindered tracking of elk shot from the ground. Immobilization attempts were made almost daily during the 2½-month period, yet only one elk was marked.

Use of a helicopter was more successful. Denney (1966) also successfully immobilized elk from a helicopter, and Bergerud *et al.* (1964) used this technique for moose immobilization. A helicopter could be used not only to accurately deliver a dart at close range, but also to herd animals into large prairie areas. When an elk was on the prairie and hit with a dart, it could be observed from the time of drug injection to immobilization.

The use of a helicopter was expensive ($110 per hour), but more efficient than immobilizing free-ranging elk on the ground (Table 2). The corral trap method was the least expensive technique used because the corral was often checked incidentally to other work, and thus transportation and labor costs were relatively small; however, only bull elk that ranged near the trap were captured.

Dosages used by Flook *et al.* (1962) on Rocky Mountain elk in Canada (20-25 mg for cows, 25-35 mg for bulls) were similar to those in this study, but Harper (1965) used lower dosages (8-30 mg, $\bar{x}$ = 13.8 for cows; 10-20, $\bar{x}$ = 14.0 for bulls) to immobilize Roosevelt elk (*Cervus canadensis roosevelti*) in Oregon. Denney (1966) also used lower dosages (average effective dose 15-20 mg for cows) for Rocky Mountain elk in Colorado. Craighead *et al.* (1973) used an average of 1 mg per 45 lbs of body weight for Rocky Mountain elk in Yellowstone National Park. Because I was unable to weigh elk at Wind Cave, dosage per unit body weight cannot be estimated. Dosages necessary to successfully immobilize adult bulls and cows in this study differed significantly ($P < 0.05$), probably because of weight differences. Latent periods (time between a hit and collapse) for successfully immobilized adult bulls and cows were not significantly different ($P > 0.05$); these times ranged from five to 15 minutes. In immobilizing free-ranging elk on the ground, such variability may make the difference between finding and not finding an immobilized animal. Cows immobilized from a helicopter ran up to two miles before collapsing. Although unlikely, it is possible for elk immobilized from the ground to do the same. There was no significant difference ($P > 0.05$) between adult bulls and cows in periods of immobilization.

There was no significant difference ($P > 0.05$) between successful and fatal dosages used on adult bulls. Tolerance to the drug varied among individual elk, perhaps depending on their physical condition. Nine adult bulls estimated as being of equal weight were immobilized with 27 mg, yet four died. Five bulls were successfully immobilized with larger dosages, including one where 35 mg was used.

Four of the 12 bulls immobilized the same day as their capture in the corral trap died of overdoses. Thirteen other bulls were allowed to rest one day between capture and immobilization, and only two of these died. Elk given a day to become calm after capture seemed to react more favorably to the drug; however, the difference by chi-square test is not significant ($P > 0.05$).

Latent periods for overdose bulls ($\bar{x}$ = 4.3 minutes) were generally less than for those successfully immobilized ($\bar{x}$ = 8.8 minutes); these times were significantly different ($P < 0.01$). Latent periods for overdosed and successfully immobilized cows were not different ($P > 0.05$); latent periods for two cows overdosed were two and 15 minutes.

Several darts shot from the helicopter bounced out immediately after impact on the animal, so the drug may not have been fully injected. The high velocity of the dart shot at close range or the elk's thick winter coat may have caused darts to bounce out. Barbless needles tended to bounce out more readily than barbed needles. However, one cow was shot three times with barbed needles before it was immobilized; the first two darts bounced out, and it was assumed that no drug was injected. In addition, Harper (1965) found that barbed needles usually remained in the elk until the animal collapsed, thus reducing the dart loss. I preferred to use barbless, collared needles at the corral trap because of the ease with which darts could be removed.

Dart malfunctions also occurred. Three of the darts los' during helicopter immobilization were later found, and o'

dart had failed to fire. Extremely cold temperatures (0°F) that occurred during part of the helicopter immobilization attempts may have caused the silicone lubricant used within the dart to congeal and prevent instantaneous injection of the drug.

Twenty-six elk were immobilized and marked by using succinylcholine chloride during this study. This drug was adequate for adult bulls captured in the baited corral trap and for female elk immobilized from a helicopter. The drug was inadequate for immobilization of free-ranging elk when drive, stalking, or blind methods were used. Perhaps more elk could have been marked with a faster-acting drug.

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